HERITAGE LISTING OF INVERTEBRATE SITES IN SOUTHEASTERN AUSTRALIA

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A pilot project has been carried out to examine the feasibility of listing sites on the National Estate Register based on invertebrates values. As a result, 30 sites in southeastern Australia have been nominated. The criteria used for registration were the same as those used for registration of cultural, historical and other natural sites. The method of selecting sites is described and all sites for which nominations were prepared are briefly discussed together with the reasons for listing them. The majority of sites were small, discrete habitats (for example, mountains tops, caves and remnant patches of vegetation) that contained a rare species of Gondwanan relationships. About one third was on private land and nearly half was 10ha or less in size. The major threats were tourism and recreation followed by alteration of hydrological characteristics. It was found that taxa that are not site specific cannot easily be protected by National Estate listing. I conclude that listing has value. It gives a measure of protection to habitats and alerts the wider community to their value. It has advantages over protecting individual species because, in practice, it is possible to legislate for only a few species and such legislation does not simultaneously confer protection on the species' habitat. ☐*Invertebrates, National Estate, southeastern Australia, listing.*

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The protection of invertebrate biodiversity in Australia is now accepted as an issue worthy of serious consideration in conservation. Attempts to protect invertebrates, however, are hampered by what has been termed 'the taxonomic impediment'. To that should be added the 'distributional and ecological impediments', since lack of information of the ecology and distribution of species is similarly limiting. Further, protection by listing invertebrate species individually is obviously impractical in an estimated fauna of over 200,000. Moreover, a network of reserves selected to represent all vegetation associations, will not protect all invertebrates, of which a proportion, estimated at about 10%, have highly localised distributions and are not bound to any recognised vegetation type.

It follows that conservation of invertebrate biodiversity should be through protection of species' habitats. Nominating specific invertebrate habitats for National Estate listing is one method of protecting them. This is the only method that is currently economically possible in most States. Once sites are listed, however, they are not legally protected as reserves, but listing gives them an established measure of protection from developments, in particular from those by government bodies.

The criteria for listing sites are specific and are formulated so that they can be applied to all types of sites from aboriginal cave paintings to the Great Barrier Reef and the Sydney Opera House. Those that are relevant to invertebrates are listed in Table 1, although it should be noted that no definition of a rare or endangered species is given by the Australian Heritage Commission (AHC).

Although several thousand sites had been listed on the National Estate Register in Australia for their natural or cultural values, up to 1990, none had been listed solely for invertebrate values. Consequently, the AHC established a project to examine the feasibility and value of listing invertebrate sites and began with a pilot scheme in southeastern Australia. It was decided 30 sites in Victoria, New South Wales, South Australia and the Australian Capital Territory would be a good basis for assessing the feasibility of extending the project nationwide.

I report the results of the AHC pilot study in this paper.

METHODS

For the consultation process, it was important that as many professional and amateur inver-

TABLE 1. Criteria for the register of the National Estate compiled by the Australian Heritage Commission November 1988 that are relevant to invertebrate values.

1.1	Be important in the evolution of Australian fauna.
1.2	Be important in maintaining existing processes of natural systems at the regional or national scale.
1.3	Be important in exhibiting unusual richness or diversity of fauna.
2.1	Be important for rare, endangered or uncommon fauna, communities, ecosystems or phenomena.
3.1	Be important in demonstrating the principal characteristics of the range of ecosystems, the attributes of which identify them as being characteristic of their class.
4.1	Be important for their close associations with individuals whose activities have been significant within the history of the nation, state or region.
5.1	Be important as places highly valued by a community for reasons of educational associations.
7.1	Be important for information contributing to wider understanding of Australian natural history by virtue of their use as research sites, teaching sites, type localities, reference or benchmark sites.

tebrate biologists as possible be approached during the process of selecting sites for nomination. To this end, the project was advertised through the Australian Entomological Society's quarterly newsletter and a poster was exhibited at the Society's annual meetings of 1991 and 1992.

A committee of three persons, including an amateur naturalist, was established in each state to solicit suggestions, consider their relevance to the criteria and assess the feasibility of preparing a nomination. As far as possible, all relevant collectors were consulted and often the nomination was completed by the person suggesting the site. In Victoria, only taxa that had been listed by the *Flora and Fauna Guarantee Act* 1988 (see Butcher et al., this volume) were chosen. In the other States, where legislation of this kind did not exist, the sites were chosen to cover as wide a range of different taxa, ecosystems, biomes and types of site as possible.

The nomination form was comprehensive and nearly thirty pages long. The information sought was as follows:

The exact location and boundaries of the nominated site were required, including details of ownership, current usage and size; and names of the State and Local administrative area in which it was found. A detailed description should follow including geological, botanical as well as faunistic information, all of which should be thoroughly referenced. Five pages of multiple choice options covering the same information was next with the inclusion of landscape characteristics. Then there were three pages dealing with the significance of the site, which had to be carefully detailed both with reference to the Heritage criteria, and in a separate discussion. The integrity and condition of the site then had to be documented, requiring a visit to it, and then a justification of the boundaries was requested. Lastly, there was space for a bibliography and names and addresses of personal contacts. Attachments were requested, some of which were mandatory, including maps at various scales (three is normally the minimum) photographs of the site and illustrations of the invertebrates present. Other relevant documents (e.g. copies of scientific papers and reports) could be attached. Preparation of a nomination usually took about two weeks.

Once received by the Heritage Committee, the nomination was rigorously checked and refereed by the Commission's own officers. Two committee stages had to be passed before proceeding to the final stage, which entailed publication on an 'Interim List' in the press for public comment. These comments had to be considered before the site was finally accepted on the register and entered into the data base. Consistency of standards was ensured internally by the Heritage Commission, in particular during scrutiny by the Board of Commissioners.

In assessing nominations, the most straightforward were those that had species and habitats that were highly localised. The species tended to be those of high conservation value because they were apparently rare and/or living in habitats particularly sensitive to disturbance. Mostly they were species of Gondwanan relationships, which often occurred on sites such as mountain tops, caves or isolated water bodies.

Because this was a pilot project investigating the feasibility and wider application of nominations, it was decided to include at least one site representative of each of the criteria in Table 1. Sites were generally selected so that a representative range of reasons for listing were included, e.g. significant type localities; historical and educational importance; rare and endangered species; and high species richness. One nomination (Castelreagh Woodlands) protected the habitat of a diverse non-site specific taxon, the jewel beetles. It listed remnant native vegetation over a large area, including corridors, to allow for movement of the beetles, thereby increasing the possibility of detecting host plants; and buffering against unpredictable environmental variability.

Suggestions for nominations amounted to several hundred possible sites. From these, 30 were chosen as representative of the whole. Sites that were the only known habitat of a genus, or higher taxon, were selected in preference to those containing merely an endemic species of a more widely distributed genus because areas of endemism for higher (supra-specific) taxa carry more 'phylogenetic diversity' than those with only endemic species. For practical reasons, sites for which there was most information were preferred.

Sites carrying the following taxa emerged as priorities for nomination:

1. Gondwanan relict species, often described as 'living fossils' whose distributions were well-known.
2. Taxa occupying geographically discrete sites such as mountain tops, caves, sink holes and mound springs, whose distributions were well-known because the habitat was well-defined.
3. Taxa that congregate at some point during their life history, such as Lepidoptera on hill tops and in various aestivation/hibernation sites, whose distributions were also relatively well-known.
4. Taxa presently occupying a severely fragmented habitat in remnant vegetation but, from historical records, are believed to have once been more widespread.

Sites could not be nominated for taxa that were not strongly tied to particular localities. Some examples are given below:

1. Large groups of species belonging to the highly diverse endemic radiations in Australia with distributions often centred in the *Acacia/Eucalyptus* woodlands and forests. Examples are found among the Psyllidae, Eurymelidae (Hemiptera), Chrysomelidae and Curculionidae (Coleoptera) and Oecophoridae (Lepidoptera). Sites that contained non-site specific taxa, however, could qualify if the fauna was unusually diverse because the diversity was site specific.
2. Taxa that might be rare but were also highly vagile, e.g. King Stag Beetle, *Phalacrognathus muelleri* (Macleay), a Canberra gryllacridid, *Cooraboorama canberrae* Rentz, and the Golden Stag Beetle, *Lamprima aurata* Latreille, of South Australia.

Also impractical for listing were microhabitats that were unpredictably impermanent despite the long period of time they took to develop, for example, rotten logs, fungal fruiting bodies (bracket fungi), moss and deep leaf litter. These microhabitats were not site specific.

TABLE 2. Summary of taxa for which nominations were prepared.

Taxa	No. of Sites	Taxa	No. of Sites
Oligochaeta	1	Diptera	1
Crustacea	2	Coleoptera	4
Araneae	1	Lepidoptera	7
Plecoptera	3	Hymenoptera (Formicidae)	1
Odonata	1	Mollusca	1
Ephemeroptera	1	Various	5
Orthoptera	1		

It also became clear that sites in remote regions were difficult to nominate because of the difficulty of access. This was particular relevant in the case of the mound springs and Ooldea Soak sites, which were not directly visited.

A number of other taxa or sites were suggested but found to be inappropriate for nomination:

1. Undescribed species. Until a species is described and compared with other congeners by a specialist taxonomist, there is no certainty about its status (e.g. whether it is new or, in fact, an already described species). As well, its distribution is not accurately known (e.g. whether it is restricted, or widespread and common) nor are its relationships. All this information was needed to make a decision for National Estate listing.
2. Sites thought to meet the criteria based on undescribed species were also unsuitable for the reasons given above.

Furthermore, if undescribed species were deemed acceptable, there was a danger that misguided, even fraudulent, claims could be made that were impossible to confirm or disprove, thus trivializing the process of listing.

NOMINATIONS

VICTORIA

Nominations for eight sites were submitted to the Heritage Commission and entered on the interim list.

1. Two years ago the only known site for the 'living fossil' mayfly, *Hemiphlebia mirabilis* (Selys), was a single swamp in Wilsons Promontory National

TABLE 3. Summary of land tenure

Tenure	No. of Sites
Privately owned land	9
Recreation reserves usually managed by the local council	8
Within an existing National or Conservation Park or similar reserve	6
Pastoral lease	3
Land under the control of the Forestry Commission	3
Crown land leased to the Department of Defence	2
Unallocated Crown land	1
Miscellaneous leased Crown land (for educational purposes, for waste dumps or rubbish pits etc.)	

Park. The site was vulnerable to damage from grazing, bush fires and possibly overcollecting. The species has since been found on Flinders Island and in extreme NE Tasmania.

2. The Giant Gippsland Earthworm, *Megascolides australis* (McCoy), occurs in a fairly limited, well-defined area of east Gippsland, which includes Mt Worth National Park, but also on grazed, private land. Populations are said to be declining as a result of intensive agricultural practices and overcollecting. The most significant distribution on private land was nominated. Mt Worth National Park was already listed on the National Estate and the species was added to that existing nomination.
3. The Warragul Burrowing Crayfish, *Engaeus sternalis* (Clarke), appears to be restricted to the banks of a creek in a council reserve where it is under threat from soil compaction due to trampling by stock and recreational use. The strip of creek bank that supported natural vegetation was nominated.

Three stonefly sites were nominated, all three occur on mountain tops:

4. The large Mt Stirling Stonefly, *Thaumatoperla flaveola* (Burns & Neboiss), is restricted to fast flowing streams at high altitudes on four peaks in eastern Victoria. An area of 10km^2 encompassing most of its distribution was nominated. Some sites have been destroyed by developments for ski resorts and populations are declining because of increased recreational activities in the area.
5. The Mt Donna Buang Stonefly, *Riekoperla darlingtoni* (Illies), is small and wingless and restricted to an area within 1km of the summit. Its habitat is small temporary streams under closed forest, which is threatened by heavy visitation and the building of more tourist facilities such as car parks.
6. The Otway Ranges contain a rare, large primitive stonefly, *Eusthenia nothofagi* (Zwick). Only a few specimens were known until it was recently recollected from two small sites. Both these sites have been nominated and are within National or State Parks. The sites are threatened by forestry activities, including land clearance, which alters stream characteristics.

The last two sites in Victoria are important hill-topping sites for butterflies.

7. Since the nomination was submitted, the Mt Piper butterfly community has been studied intensively. It includes at least two threatened lycaenids: Small Ant-blue, *Acrodipsas myrmecophila* (Waterhouse & Lyell) and the Large Ant-Blue, *A. brisbanensis cyrilus* (Anderson & Spry). Its natural values are now very much appreciated by the local community as a significant feature of the town. The site is being rehabilitated and appears secure. It is described and discussed in more detail by Jelinek et al. (this volume).
8. A series of small dunes, only 4km^2 in area, in mallee country, NW Victoria, supports a unique assemblage of butterflies including the rare and endangered Small Brown Azure (*Ogyris otanes* Felder & Felder). The location is being kept confidential to protect the species from overcollecting. Damage from placement of a trig point and access road has occurred recently.

AUSTRALIAN CAPITAL TERRITORY

Two sites were selected for nomination and have been placed on the interim list.

1. *Keyacris scurra* (Rehn) is a morabine grasshopper whose distribution has decreased since settlement. It now occurs only in small disjunct patches of native *Themeda* grassland or *Chrysocephalum* herbfield. One small population (ca. 2000 individuals) in Tidbinbilla National Park could be subject to damage by recreation and fire. The 0.5ha of land carrying the population was nominated.
2. Castniids are a family of conspicuous dayflying moths. One species, *Synemon plana* Walker, was widespread in southeastern Australia before settlement, according to early collection records. It is now restricted to a few remnant patches of *Danthonia* grassland. The largest of these, the Belconnen Naval Station, was nominated but it is scheduled for resumption by the State Government for urban expansion.

NEW SOUTH WALES

Ten sites have been nominated in this State and all have been submitted:

1. Harrington-Crowdy Head rainforest in the northern part of the State is a strip of littoral rainforest in good condition, about 4km long, which is the type

TABLE 4. Summary of habitats, ecosystems, biomes and vegetation types.

Habitat	No. of Sites
Caves	1
Sink holes	1
Mound springs	1
Swamps, soaks, creeks	2
Landscape units	
Mountain and hill tops	8
Creeks	3
Remnant vegetation	7
Cliff tops, coastal strips	4
Rangelands and pastoral	3

Landscape units (except caves, sink holes and springs) can be further broken down into vegetation types as follows:

Vegetation types	No. of Sites
Rainforest	
littoral	1
gallery	1
cool temperate	1
subtropical	2
Grassland	1
Herbfield	1
Low shrubland	1
Eucalypt forest	
open	5
tall open	2
Eucalypt woodland	
open	1
low open	1
Mallee heath	3
Coastal heath	2
More than one vegetation type	
Tall open eucalypt forest, alpine and subalpine vegetation	1
Shrubland, heathland and swamp	1
Shrubland, woodland, tussock grassland	1
Sedgeland, heath	1
Low open woodland, tall shrubland, heath, sedgeland	1

locality for several dipteran and coleopteran species. It is an important research site because the fauna is exceptionally diverse. Threats to the site's integrity include invasion by weeds. A number of other relict patches of rainforest, which are of heritage value, occur along the coast in the region. Many of them are unallocated Crown land, as is the Harrington-Crowdy Head site.

2. *Paralucia spinifera* Edwards & Common, the Bathurst Copper, is one of Australia's rarest butterflies yet no populations occur in reserves. There is some evidence that it is in decline, possibly through overcollecting. Of the two sites nominated (4ha) in total area, one is leased from the Crown for use as a rifle range and the other is freehold and used as a coal mine. The natural values of both sites are being eroded by horses, control burning and recreation. The food plant also is being affected.
3. One of the richest hill-topping sites for butterflies in northern N.S.W. is Mt Ramornie, on private land west of Grafton. Forty-nine species have been recorded there and it is the only known location for *Acrodipsas arcana* (Edwards & Miller). All land carrying native vegetation within the landholder's boundary was nominated. A number of other important hill tops for butterflies occur in the region.
4. Carrai Bat Cave, NW of Kempsey, is within a flora reserve administered by the Forestry Commission of N.S.W. Several invertebrates of importance live in the cave including *Progradungula carraiensis* Forster & Gary, a relictual, gondwanan spider that is only known from here. It is suggested that threats to the cave's integrity could come from over-use by speleological groups.
5. The Wog Wog patch experiment, established in 1985 and scheduled to run indefinitely, is located within the tall eucalypt forest of southern N.S.W. (Nicholls & McKenzie, this volume). Replicate patches of three sizes of native eucalypt forest surrounded by pine forest and control sites within intact forest have been sampled for eight years for invertebrates using pitfalls. The beetle fauna documented so far consists of nearly 650 species, a remarkably high diversity for a small area of relatively uniform eucalypt forest.
6. Fowler's Gap, situated in arid rangelands 100km north of Broken Hill, is the research station of the University of N.S.W. Numerous collections of invertebrates and ecological projects have been centred on the site during the last 25 years. Over 30 publications, mostly on Formicidae and Calliphoridae, have been the result. It is probably the best known site for invertebrates in the rangelands of N.S.W.
7. The Macleay family, active throughout the 19th century, were the first locally-based entomologists to make major collections of Australian insects. Family diaries have been published and the vast collections resulting from their work are now housed in the Macleay Museum, Sydney Univer-

TABLE 5. Summary of criteria used and all registrations.

Categories	No. of Sites
Sites with 'rare and endangered' taxa	15
Primarily species rich sites	7
Primarily type localities	3
Sites primarily with a close association with significant individuals	1
Research and/or teaching sites, bench mark sites	2
Sites which are primarily important in maintaining existing processes or natural systems at the regional or national scale	2

sity. Rope's Creek in western Sydney was a favourite collecting spot of W. Macleay and an important type locality for Buprestidae (jewel beetles). This locality has become degraded and now lacks any substantial native habitat. The Castlereagh State Forest, 3km to the north, is intact and other native vegetation remnants persist within an area of 10km^2 reaching as far as the University of Western Sydney's Hawkesbury campus, where many of Macleay's species are still found. Most of the land is Crown land. Present land use includes forestry, waste dumps, correctional services and educational sites. All relatively intact native vegetation within this area was nominated including corridors linking major remnants.

8. Mooney Mooney Creek is a holotype site for several species of Diptera, being an unusually diverse site for the order. A number of rare species are found here that are absent from nearby reserves. For this reason alone, nomination is justified. The fauna is relatively well-known because it has been regularly visited by collectors for over 30 years. Two uncommon species of Mecoptera are also found here.
9. Rotary Park within the city of Lismore is a recreation park and has the only known habitat for the large flightless carabid, *Nurus brevis* Motschulsky. The species was more widespread before the Big Scrub was cleared for agriculture. The park was already listed so the carabid was added to the registration. Rainforest is currently being restored on this site.
10. Alexandra Park near Astonville is the only known locality for *Nurus atlas* (Castelnau), also more widespread before vegetation clearance. It is a council recreation reserve and already listed as part of the National Estate. The beetle has been added to the existing registration.

SOUTH AUSTRALIA

Ten sites have been nominated in this State:

1. *Hypochrysops ignitus* (Leach), the Fiery Jewel, is extremely rare in South Australia and considered endangered. One small site on which it occurs is within the Innes National Park, York Peninsula. It is the only site known where it uses *Dodonoea humulis* as a host plant. The vegetation is coastal heath and scattered woodland and is threatened by wild fire. Three other uncommon butterflies occur on the site.
2. Another very small site (100m × 200m) of coastal heath in the same park is habitat for the rare butterfly, *Ogyris otanes*, already referred to in nomination 8 in Victoria's mallee. This species was much more widespread in South Australia earlier this century. As with the Fiery Jewel site, the greatest threat to the site is wild fire.
3. The 'dinosaur ant', *Nothomyrmecia macrops* Clark, said to be very primitive, is known only from a small patch of mallee on private land adjacent to the township of Poochera, Eyre Peninsula. A roadside site was inadvertently destroyed soon after discovery and the current population, which occurs in only 600m^2, is threatened by invasion by exotic weeds and a pest species of snail. Another population of uncertain status may occur adjacent to the town cemetery. The site was nominated together with a large area of potential habitat, which is mallee, but with a predominantly exotic grassy understorey.
4. The middle to upper slopes of Darke Peake, Eyre Peninsula, an isolated quartzite ridge with native vegetation, is the only known locality for *Nanodectes bulbicercus* Rentz. This species was certainly more widespread before land clearance for agriculture. Although the whole mountain range is already listed, the land is owned by the Australian National Railways and is in use as an expanding quarry, which seriously detracts from the National Estate values. This is one of a number of sites that need protection for rare and restricted tettigoniids.
5. Tookayerta Creek in the Mt Lofty Ranges has been noted as the most speciose site for Plecoptera (6 out of 8 species) and Ephemeroptera (6 out of 14 species) in the State. It is in private hands, heavily weed infested and its banks eroded by stock.
6. Fossil Cave is a sink hole in the southeast and the type locality for the 'living fossil' *Koonunga crenarum* Zeidler, a syncarid crustacean. The cave is also an important site for vertebrate pleistocene fossils. It is an example of many similar sink holes or drowned caves in the region, all of conservation importance.
7. 'Mygale Blowhole' or Nullarbor Cave Number 5N 253, is the sole known site for the only cave adapted trapdoor spider known, *Troglodiplura lowryi* Main. This spider is not related to any Australian spider group and its closest relatives are in South America. Fragments of specimens have been found in two other caves on the Nullarbor further north, but no live specimens. It might previously have been more widespread in caves in the region but became extinct as they became drier.

TABLE 6. Summary of threatening processes

Threatening process	No. of Sites
Tourism/recreation	12
Altered hydrological characteristics as a result of changed land use	8
Pastoral activity	7
Land development, urbanisation	6
Wild fires	6
Overcollecting	5
Weed invasion	5
Other disturbance by government instrumentalities, Telecom, trig points, etc	3
Sites with no perceived threats	2
Forestry activities	2
Arable agriculture	2
Mining and exploration	2
Controlled burning	1

Aldinga Scrub Reserve, just south of Adelaide, is one of the very few remnants of vegetation left on the Adelaide Plain. It is already listed on the Register but invertebrate values were not included with the original nomination. It is an important habitat for species previously widespread on the plains and a recent survey documented at least 540 species of invertebrate from the Reserve. These are now being added to the site's registration.

9. Hallet Cove is also already on the National Estate Register but it is also the locality for some rare Lepidoptera and the most westerly outlier of the Blue Meat Ant *Iridomyrmex lividus* Shattuck. The invertebrate fauna has been added to the previous listing.
10. Ooldea Soak used to be the railhead before the line linking Western Australia and South Australia was built. This site was nominated partly because it is an important type locality, particularly for Coleoptera and Hemiptera, but also because of its historical association with significant personalities in the development of entomology in Australia. In the early part of this century, Arthur Lea, who described more species of Australian beetle (5432) than anyone before or since, and later Norman Tindale, visited this remote site by train and collected intensively. Parts of the area around the soak are already listed because of its association with Daisy Bates and aboriginal culture. A different, larger area, which is likely to have been within range of insect collectors on foot from the railhead, and including mallee vegetation, has been nominated.

Mound springs are not included in this list, but nominations will be prepared in a separate, future project. The mound springs are known to harbour a highly endemic fauna of aquatic invertebrates, of which Crustacea and Mollusca are foremost (Ponder, this volume). All natural, unfenced springs are in urgent need of protection from trampling by stock and tourists. Management is difficult because of the springs' remoteness. The Neales Springs group includes some of the most important individual springs and invertebrate additions to existing nomination of Blanche Cup and Dalhousie Springs, where a blind amphipod occurs, will be made. Most other groups of springs such as Emerald Spring, which is the only locality known in Australia for macrostomid platyhelminths, fulfil the criteria for nomination.

DISCUSSION

The value of National Estate listing for sites with natural values has been demonstrated many times. The most publicised cases have been concerned with threats from logging to National Estate listed forests, where listing has prevented some unwise, commercial exploitation. Undoubtedly, listing is a powerful social barrier. It is too early to say what effects listing will have on the protection of invertebrate sites, although the process itself has conferred a number of benefits in raising awareness of invertebrate conservation in general.

The results of the pilot project are summarized in Tables 2-6 and illustrate some priorities in insect conservation. As might be expected, butterflies lead the list of taxa nominated because they are the best known group of invertebrates in Australia (Table 2). Within that order, lycaenids, which have a complex life cycle including a symbiotic relationship with ants, are represented disproportionately. This indicates that species can be more vulnerable if they have a complex life cycle with multiple dependencies on other plant and animal species.

Otherwise, the taxa selected showed no biases except towards those for which there were Australian specialists familiar with their systematics and distributions (Table 2). An obvious gap is the myriapods, which reflects the lack of taxonomic expertise for the group, and not that there are no rare or endangered myriapods.

A summary of the land tenure of all sites shows that the largest number of sites were either on private land or in Recreation Reserves (Table 3). These areas are not so well protected as those in Conservation Reserves. National Estate listing could prove to be of benefit here, especially in drawing the attention of owners and managers to the natural values of their land.

Although one aim for the project was to select as wide a range of different types of sites as possible, nevertheless many of those selected were hills or mountain tops (Table 4). This probably reflects their relative pristine nature as well as their conservation importance for invertebrates. The main vegetation associations involved appear to represent fairly well those present in the region of the pilot study (Table 4).

Most sites were small with only a third being larger than 100 hectares and another third smaller than 5ha (Fig. 1, 2). This illustrates the importance of small areas for the conservation of invertebrates, but does not obviate the need for much larger areas for the conservation of many Australian taxa. Priority was given to the most vulnerable and rare taxa at the beginning of the pilot study and it became clear that many of these taxa were also associated with small sites.

Table 5 lists the most important reasons for nomination. For half the sites, the criterion used was that of containing rare and endangered fauna while species richness was relevant to nearly a quarter of the sites. The justification for listing any one site, however, was not usually based on a single feature but on a range of characteristics.

Tourism and recreation were the most frequently cited threatening processes (Table 6), which may reflect, to some extent, a bias in selecting sites about which there was most information because they were accessible. Altered hydrological properties was the next most common threat, probably because a large proportion of the nominations were wetlands. Surprisingly, pollution from run-off carrying pesticides and nitrates was not mentioned, although it is likely to be an as yet undetected danger to some sites.

Pastoral activities, urbanisation, fire and weed invasion were also considered to be serious threats. Significantly, overcollecting was thought to be a threatening process for five of the sites.

CONCLUSION

The pilot study demonstrated that listing invertebrate sites was feasible. Of those nominated, about half have been processed by the Commission and placed on the Interim List (1993). It should be stressed that the 30 sites nominated in this study were only a small sample. Many more sites could have been nominated.

There has been some criticism of National Estate listing because a large number of invertebrate species, for which there is no information, were not and cannot be included. However,

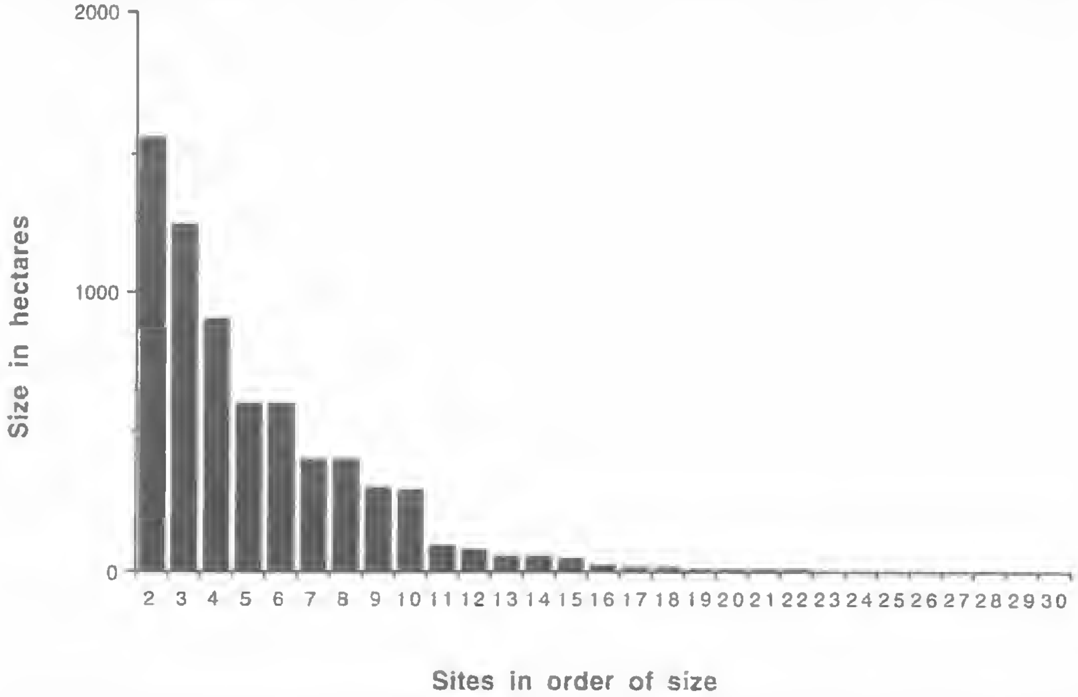

FIG. 1. Size in hectares of sites nominated in decreasing order omitting the largest, (Fowler's Gap) of 38,889ha.

this is no reason to withhold listing for those that can. Moreover, it is precisely the taxa which are of most phylogenetic and conservation interest that have attracted most attention from taxonomists and, therefore, about which most is known.

National Estate listing does not and cannot take into consideration all factors for the long-term survival of the species, but the process is vital in focusing attention on species for which recovery or action plans are needed, and for facilitating such plans. Although listing confers no legally binding obligations, owners have almost invariable welcomed information on the invertebrate fauna of their land: no negative attitudes were encountered. The only exception was from officials of a local council, who were indifferent to the proposed listing.

I list the benefits of National Estate listing below:

1. Listing gives a measure of protection to habitats, in particular, by alerting the wider community to their value. It has advantages over protecting individual species because legislation is only practical for small numbers of species and, even then, legislation does not simultaneously confer protection on habitats.
2. Sites with all types of land tenure can be listed including private land. Permission from land owners need not be sought but they are always consulted by the Australian Heritage Commission before listing occurs and encouraged to continue protection of the site.
3. National Estate listing has been criticised because it is said that the legislation is not strong enough to prevent destruction of a listed site. State and Local Governments need not consider National Estate listing when giving planning or development approvals, but many States do. The Federal government is, however, obliged to do so, although under the Act it can over-ride listing. State planning bodies, at least in the A.C.T and South Australia, keep lists of registered sites for consultation when assessing planning applications. The Intergovernmental agreement on the environment signed by all States except Tasmania, in February 1992, states that the States and Commonwealth 'agree that the register of the National Estate is one of the factors that the States may consider when making land use and resource planning decisions...The parties recognise... that some applications of S.30 of the Act (Australian Heritage Commission Act 1975) may have significant land and resource use planning implications' (my emphases).
4. Registration has an important benefit because consultation has to be undertaken during preparation of the nomination with a wide range of people including: both professional and amateur biologists, landowners, government employees (of different kinds and at all levels), non-governmental organisations and some members of the public. This results in a wider appreciation, not only of the conservation of Australian invertebrates, but also of the value and widespread applicability of National Estate listing for the protection of Heritage.

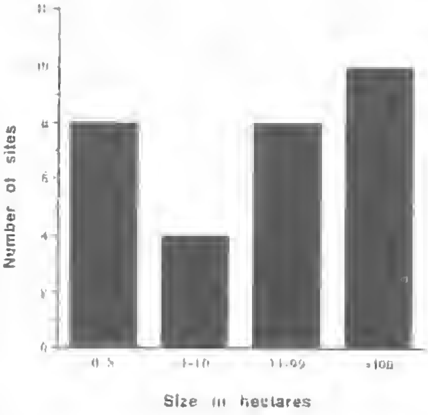

FIG. 2. Nominated sites classified into four groups by increasing size.

5. Preparing a nomination involves research on the taxon (or group of taxa) for which protection is sought and also on the ecological and other features of the site itself. The nomination therefore provides baseline data from which action, recovery or other management plans can be written. Documenting threatening processes at every site has been most valuable in this respect. An example is *Nothomyrmecia macrops*, which has been studied intensively by taxonomists and behaviourists, but for which management issues had so far been neglected.
6. Because of our lack of taxonomic, ecological and distributional knowledge of much of Australian invertebrate biodiversity, there are inherent difficulties in protecting it. Adequate protection is dependent on having a sufficiently large pool of taxonomic expertise. Through nomination, well-known species can act as umbrella species for the suite of lesser-known invertebrates that are part of the same ecological community.
7. An original prediction of about a hundred invertebrate sites for the whole of Australia was underestimated by at least one order of magnitude. Four States still have to be considered and there remains an extensive list of sites from southeastern Australia, compiled during the course of this project, for which nominations have yet to be prepared.

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LITERATURE CITED

References to data listed in the paper are numerous and are all recorded on the nominations, copies of which are available from the author and the Australian Heritage Commission.